

# Innovative design of hybrid reverse osmosis and multi-stage flash desalination plants

Vince François<sup>1</sup>, Marechal François<sup>2</sup>, Bréant Philippe<sup>1</sup>, Aoustin Emmanuelle<sup>1</sup>

<sup>1</sup> DRDT, Veolia Environnement, 17-19, av. La Pérouse, 75116 Paris, France

<sup>2</sup> Industrial Energy Systems Laboratory, Swiss Federal School of Technology, 1015 Lausanne, Switzerland

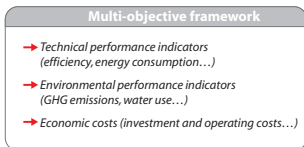
francois.vince@veolia.com

## GOAL:

The purpose of this work is to develop a decision support tool, which will systematically assess the advantages of hybrid desalination configurations (integration between thermal and membrane technologies) by investigating and optimizing these configurations as a function of project requirements and local conditions.

## INITIALIZATION:

- Definition of context and project requirements
- Definition of performances indicators and objectives
- Definition of suitable desalination equipments



Reverse Osmosis Pressure Vessels

**Local context and project requirements**

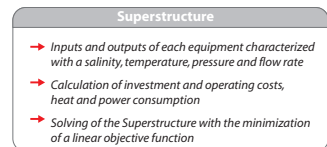
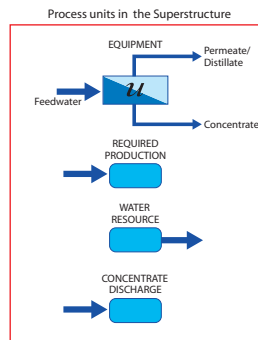
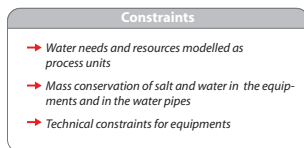
- Capacity and quality needed of desalinated water
- Amount and quality of local energy and water resources
- Project local constraints and conditions (plant location, energy cost,...)

**List of desalination equipments**

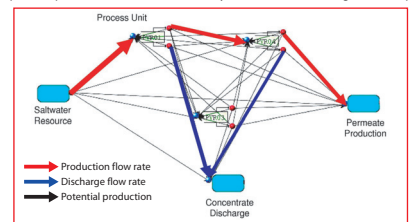
- Thermo-dynamic models of the technologies
- Multi-stage flash distillation (MSF BR) (Heat Recovery and Heat Rejection section)
- Brackish water Reverse Osmosis (BWRO)
- Seawater Reverse Osmosis (SWRO)

## GENERATION OF SOLUTIONS:

- Hybrid desalination configuration defined by:
  - the choice of desalination equipments
  - the sizing of these equipments
  - the interconnecting piping network
- Systematic generation within a flexible Superstructure of all the feasible configurations which respect the project requirements
- Linear modelling of the Superstructure defined by a set desalination equipments implemented as **process units**

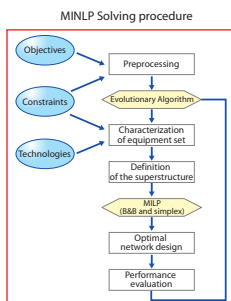


Example of Superstructure with one feasible hybrid desalination configuration displayed



## OPTIMIZATION:

- Formulation of the design synthesis and optimization problem as a Mixed Integer Non Linear Programming (MINLP) Problem
- Resolution by decomposition into:
  - a Master **Non Linear Problem** (optimization of equipments) solved with evolutionary algorithm,
  - a Slave **Linear Problem** (optimization of sizing and piping network), solved with conventional mixed integer linear programming algorithms.
- Multi-Objective Optimization (MOO) of the configurations based on the performance indicators (specific cost in €/m<sup>3</sup> and water resource conversion rate in m<sup>3</sup> of desalinated water per m<sup>3</sup> of seawater)
- Optimal solutions represented by points on the so-called **Pareto curve**



## CASE STUDY:

- Seawater quality: 35000 ppm
- Capacity desired: 40000 m<sup>3</sup>/day
- Permeate quality: 100 ppm
- Objectives: Annual costs and water conversion rate

